DOCUMENT RESUME

ED 145 007 UD 017 275

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TITLE Mathematical Cognitive Structures of Junior High Students Educated in the United States and of Those Recently Arrived from Hong Kong, an Exploratory Study.
INSTITUTION Berkeley Unified School District, Calif. Asian American Bilingual Center.
SPONS AGENCY Office of Education (DHEW), Washington, D.C.
PUB DATE Jan 77
NOTE 20p.
AVAILABLE FROM Asian American Bilingual Center, 2168 Shattuck Avenue, Berkeley, California 94704

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage.
DESCRIPTORS *Asian Americans; *Cognitive Processes; *Cognitive Tests; Comparative Analysis; *Junior High School Students; *Mathematical Concepts; Secondary Education
IDENTIFIERS *California (Oakland); *Hong Kong; United States

ABSTRACT

This is an exploratory study comparing the mathematical cognitive structure of a group of junior high students educated in the United States with that of a group of students recently arrived from Hong Kong. The word association technique was employed to retrieve the mathematical cognitive structures from both groups of students. The word association data were subsequently converted to two dimensional graphical representations by the multidimensional scaling procedure. The results of the two dimensional graphical representations indicated that the mathematical cognitive structures of the two groups of students were different. The difference between the mathematics curricula of the United States and Hong Kong was suggested as the possible cause for the difference in the mathematical cognitive structures. It is suggested that this study be replicated with other ethnic groups for immediate application to bilingual education programs. (Author/AM)

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ED145007

Mathematical Cognitive Structures of Junior High Students Educated in the United States and of Those Recently Arrived from Hong Kong, an Exploratory Study

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January, 1977

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ASIAN AMERICAN PERSPECTIVES ON EDUCATION is a continuing series of monographs intended to spark debate and action among those concerned about equal and quality education for all children in the United States. Topics included in the series range from preschool education in China and its implications for American early childhood education to the advocacy of a particular model for Filipino bilingual education programs in the United States.

The series was born as the result of the Asian American Bilingual Center's efforts to develop bilingual multicultural curriculum of relevance to classrooms throughout the country. Funded by ESEA Title VII in 1975 to produce educational materials for Asian American children of Chinese, Filipino, Korean, Japanese and Samoan heritage, the Center initiated the publication of a national newsletter. The newsletter not only attempts to inform interested persons in the specific work of the project but also features a supplement which highlights a more general educational issue. Contributors have included Ling-chi Wang, Estela Pinga, NVM Gonzalez and Itty Chan. Their articles have stimulated great interest among the one thousand readers of the newsletter. Thus, ASIAN AMERICAN PERSPECTIVES ON EDUCATION was conceived.

In this issue, "Mathematical Cognitive Structures of Junior High Students Educated in the U.S. and Those Recently Arrived from Hong Kong," written by Sau-Lim Tsang, is presented. Sau-Lim Tsang is currently the Center's Evaluator. Born in Shanghai and a graduate of the University of California, Berkeley, Tsang has a secondary teaching credential and holds two master's degree and a Ph.D. in the fields of international education development, statistics and math education respectively.

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Mathematical Cognitive Structures of
Junior High Students Educated in the United States
and of Those Recently Arrived from Hong Kong,
An Exploratory Study

Mathematical concepts exist in a structure. Mathematics educators define this structure as "a set of interrelated, abstract, symbolic systems [SMSG Newsletter No. 39, 1972, p. 5]." The "new math" movement of the sixties in the United States was an attempt to incorporate the structure of mathematics in school curricula and to introduce this structure systematically to the students, beginning in the early grades (Report of the Commission of Mathematics, 1959; Report of the Cambridge Conference, 1963). The mathematics curricula of today emphasize the meaning of algorithms and operations, and the relationships of mathematical concepts in the mathematical structure.

While, in the United States, the mathematical structure has been introduced to students for over fifteen years through revolutionized mathematics curricula, many other countries are still using traditional mathematics curricula that emphasize computational skills, especially at the primary and elementary grade levels. Hong Kong is an example of these places. The differences of the mathematics curricula in the United States and Hong Kong might have an effect on the learning of mathematics by the students. This study compares the structures of eighteen mathematical concepts as they are conceived by a group

of Anglo 7th and 8th graders born in the United States and as they are conceived by a group of Chinese 7th and 8th graders recently arrived from Hong Kong.[1]

The mathematical structure conceived by the students in their memories is referred to as the students' mathematical cognitive structure. Researchers have, in recent years, demonstrated many methods of retrieving the cognitive structure from the students' memories (Adams, 1967; Bruner, et al. 1966; Bousfield, 1953; Cofer & Musgrave, 1963; Schuell, 1969; Coombs, 1964; Menges, 1969; Osgood, Suci & Tannenbaum, 1957). Most of the methods used some forms of similarity judgments, response clustering, or free and constrained associations. Deese (1965) and Dixon & Horton (1968) have presented historical surveys of these research efforts. The reviews will not be reiterated here.

The present study employs the Word Association technique to obtain estimated proximities of a mathematical concept in relation to other concepts. The technique involves giving the students a set of stimulus words, and, for each word, asking the students to write down as many related words as they can think of within a certain time limit. The validity of this technique has been demonstrated in studies conducted by

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[1]The researcher gratefully acknowledges the cooperation and assistance of the following persons: from Westlake Junior High of Oakland, California: Mr. Rolph Chin, Principal, and Ms. Josephine Lee, teacher; and from Hyde Junior High of Cupertino, California: Mr. Jack Belote, Principal, and Ms. Laurene Stones, teacher.

Shavelson (1970), Geeslin (1973), and Begle, Pence & Tsang (1975). The proximity data obtained for the set of stimulus words were converted to graphical representations using the multi-dimensional scaling procedure developed by Shepard (1962a, 1962b) and Kruskal (1964a, 1964b).

Method

Sample

Two groups of students were selected to participate in the study: Group A consisted of students educated in the United States and Group B consisted of students recently arrived from Hong Kong.

Group A was selected from a junior high school in the Cupertino Union School District in California. Cupertino Union School District has a predominantly white population (92%) and is of the middle socio-economic status (California State Testing Program, 1974). A mixed 7th and 8th grade mathematics class of thirty students participated in the study. All but one of the thirty students received their primary and elementary schooling in the United States, that is, they received their mathematics education only from the curricula of the United States. One of the students in the group only recently moved to the United States and her data were excluded from the analysis.

Group B was selected from a junior high school in Oakland, California. Oakland is one of the cities that have large concentrations of Chinese immigrants from Hong Kong and Taiwan. Chinese bilingual education programs were incorporated in the regular school programs to serve the special needs of the Chinese students. A mixed 7th and 8th grade bilingual class of twenty-five students participated in the study. All twenty-

five students were recent immigrants. None of them had lived in the United States for more than two years. Of these twenty-five students, one came from Japan and two from Taiwan. Their data were excluded from the analysis. The other twenty-two were from Hong Kong and received most of their mathematics education from the curricula of Hong Kong.

Word Association test

Content analyses were performed on several primary and elementary mathematics textbook series of the United States and Hong Kong. Eighteen mathematical concepts were selected for the study because they were introduced in all the textbook series analyzed. These concepts were ADDITION, AREA, CIRCLE, CUBE, DECIMAL, DIVISION, FRACTION, INTEGER, LINE, MULTIPLICATION, PERCENTAGE, PERIMETER, POINT, RATIO, RECTANGLE, SUBTRACTION, TRIANGLE, and VOLUME.

A Word Association test booklet was prepared using the eighteen mathematical concepts. Page one of the booklet consisted of explanations and instructions. Page two was a practice example. The word ANIMAL was written on top of this page as the stimulus word. The practice example was followed by eighteen pages. At the top of each page was one of the selected concepts written as the stimulus word. The eighteen mathematical concepts were randomly sequenced in each booklet to prevent a sequence effect. The test booklet administered to Group B was written bilingually in English and Chinese to facilitate comprehension for the limited English speaking students.

Procedures

The Word Association test was administered to the students in the early part of 1976. Test procedures were identical for both groups except that the test instructions were given bilingually (English/Chinese) to the students in Group B, and the students were instructed to write their responses in either Chinese or English. The same test administrator, who was bilingual in English and Chinese, administered the test for both groups. Students were read the instructions on the front page of the test booklet. After all questions were clarified they turned to the second page and tried out the practice example ANIMAL. Additional questions were answered, and then, for the rest of the test, the students were instructed to write down as many mathematical terms as they could think of related to each stimulus word. One minute was allowed for every page with a one-minute break after the ninth stimulus word.

Analysis

The Word Association data from each student were converted to an 18 x 18 matrix by calculating the relatedness coefficient between each pair of the 18 mathematical concepts. The details of this procedure were reported by Shavelson (1970) and Geeslin (1973). This matrix is called the relatedness coefficient matrix (RC matrix). Two mean RC-matrices, one for Group A and one for Group B, were obtained by averaging each element of the matrices over the students in each group.

The mean RC-matrices were then submitted to the multidimensional scaling procedure which converted the mean RC-matrices

into two-dimensional graphical representations. On the graphical representations, the eighteen mathematical concepts were scattered around the two axes as points. The positions of the two orthogonal axes were arbitrarily placed to facilitate the calculation of the Euclidean distance between each pair of points. The placement of a point in a certain quadrant of the graph does not bear significant interpretation except for its relative distances from the other points. The actual conversion procedures were performed by the computer program M-D-SCAL (Kruskal, Carmone, & Arabie, 1976).

Results and Discussion

The two groups of students reacted differently to the Word Association Test. Students in Group A responded to each stimulus word with enthusiasm and averaged 14.53 (N=29) responses per stimulus word. Students in Group B responded as enthusiastically to the practice example ANIMAL as the students in Group A but showed diffidence in responding to the mathematical stimulus words. Nine of the Group B students failed to write down any response to any of the eighteen stimulus words and their data were eliminated from the analysis. The remainder of the Group B students averaged 5.68 (N=13) responses per stimulus word, and this is significantly lower than than of Group A ($t=5.11$, $p<.05$). Two factors might account for this difference. It could be due to the nature of the mathematics education introduced to the Group B students in Hong Kong. Or the students from Hong Kong were not as accustomed to non-traditional testing techniques as the students educated in the United States. Either one or both of these reasons could have led to the diffidence of the Group B students in the testing.

Two mean RC-mean RC-matrices were calculated: one for Group A, and one for Group B. The two mean RC-matrices are reproduced in Table 1 and Table 2.

Table 1: Mean RC-matrix of Students in Group A.

	ADDITION 1	AREA 2	CIRCLE 3	CUBE 4	DECIMAL 5	DIVISION 6	FRACTION 7	INTEGER 8	LINE 9	MULTIPLICATION 10	PERCENTAGE 11	PERIMETER 12	POINT 13	RATIO 14	RECTANGLE 15	SUBTRACTION 16	TRIANGLE 17	VOLUME 18
1	1.00	.009	.003	.008	.011	.098	.015	.025	.004	.113	.006	.034	.007	.008	.005	.164	.001	.015
2	.009	1.00	.149	.155	.005	.017	.004	.009	.009	.022	.003	.190	.006	.024	.116	.009	.044	.149
3	.003	.149	1.00	.057	.014	.001	.007	.008	.016	.008	.000	.123	.036	.020	.087	.009	.050	.045
4	.008	.155	.057	1.00	.004	.021	.005	.007	.045	.008	.002	.125	.020	.009	.155	.007	.097	.188
5	.011	.005	.014	.004	1.00	.031	.118	.011	.033	.014	.053	.012	.213	.027	.005	.028	.005	.008
6	.098	.017	.001	.021	.031	1.00	.037	.019	.001	.144	.009	.016	.009	.023	.010	.078	.003	.016
7	.015	.004	.007	.005	.118	.037	1.00	.029	.008	.015	.065	.005	.024	.031	.004	.018	.000	.002
8	.025	.009	.008	.007	.011	.019	.029	1.00	.010	.025	.020	.020	.010	.014	.006	.029	.004	.007
9	.004	.009	.016	.045	.033	.001	.008	.010	1.00	.002	.000	.055	.201	.006	.012	.005	.029	.021
10	.133	.022	.008	.008	.014	.144	.015	.025	.002	1.00	.010	.031	.004	.009	.007	.110	.002	.017
11	.006	.003	.000	.002	.053	.009	.065	.020	.000	.010	1.00	.004	.010	.031	.001	.005	.000	.002
12	.034	.190	.128	.125	.012	.016	.005	.020	.055	.031	.004	1.00	.008	.026	.104	.029	.080	.070
13	.007	.006	.036	.020	.213	.009	.024	.010	.201	.004	.010	.008	1.00	.006	.030	.008	.035	.010
14	.008	.024	.020	.009	.027	.023	.031	.014	.006	.009	.031	.026	.006	1.00	.014	.010	.020	.015
15	.005	.116	.087	.155	.005	.010	.004	.006	.012	.007	.001	.104	.030	.014	1.00	.004	.132	.047
16	.164	.009	.009	.007	.028	.078	.018	.029	.005	.110	.005	.029	.008	.010	.004	1.00	.002	.021
17	.001	.044	.050	.097	.005	.003	.000	.004	.029	.002	.000	.080	.035	.020	.132	.002	1.00	.024
18	.015	.149	.045	.188	.008	.016	.002	.007	.021	.017	.002	.070	.010	.015	.047	.021	.024	1.00

Table 2: Mean RC-matrix of Students in Group B.

	ADDITION 1	AREA 2	CIRCLE 3	CUBE 4	DECIMAL 5	DIVISION 6	FRACTION 7	INTEGER 8	LINE 9	MULTIPLICATION 10	PERCENTAGE 11	PERIMETER 12	POINT 13	RATIO 14	RECTANGLE 15	SUBTRACTION 16	TRIANGLE 17	VOLUME 18
1	1.00	.000	.000	.000	.000	.000	.000	.004	.000	.040	.000	.000	.000	.000	.011	.061	.024	.000
2	.000	1.00	.102	.076	.000	.000	.000	.000	.000	.000	.000	.157	.000	.000	.190	.000	.183	.128
3	.000	.102	1.00	.014	.004	.006	.007	.000	.017	.000	.004	.098	.000	.000	.060	.000	.041	.049
4	.000	.076	.014	1.00	.000	.000	.000	.000	.000	.000	.000	.035	.000	.000	.101	.000	.048	.223
5	.000	.000	.004	.000	1.00	.043	.121	.000	.000	.000	.093	.000	.203	.000	.000	.000	.000	.000
6	.000	.000	.006	.000	.043	1.00	.113	.029	.000	.021	.041	.000	.000	.026	.008	.024	.000	.000
7	.000	.000	.007	.000	.121	.113	1.00	.060	.000	.037	.153	.000	.024	.013	.000	.008	.015	.000
8	.004	.000	.000	.000	.000	.029	.060	1.00	.000	.000	.024	.000	.013	.017	.000	.000	.005	.000
9	.000	.000	.017	.000	.000	.000	.000	.000	1.00	.000	.000	.023	.078	.000	.020	.038	.009	.003
10	.040	.000	.000	.000	.000	.021	.037	.000	.000	1.00	.000	.000	.000	.000	.011	.061	.024	.000
11	.000	.000	.004	.000	.093	.041	.153	.024	.000	.000	1.00	.017	.027	.043	.000	.008	.010	.000
12	.000	.157	.098	.035	.000	.000	.000	.000	.023	.000	.017	1.00	.000	.000	.096	.000	.135	.053
13	.000	.000	.000	.000	.203	.000	.024	.013	.078	.000	.027	.000	1.00	.000	.000	.000	.000	.000
14	.000	.000	.000	.000	.000	.026	.013	.017	.000	.000	.043	.000	.000	1.00	.000	.013	.000	.000
15	.011	.190	.060	.101	.000	.003	.000	.000	.020	.011	.000	.096	.000	.000	1.00	.000	.136	.105
16	.061	.000	.000	.000	.000	.024	.008	.000	.038	.061	.008	.000	.000	.013	.000	1.00	.010	.000
17	.024	.183	.041	.048	.000	.000	.015	.005	.000	.024	.010	.135	.000	.000	.136	.010	1.00	.066
18	.000	.128	.049	.223	.000	.000	.000	.000	.003	.000	.000	.053	.000	.000	.105	.000	.066	1.00

The element in the matrices represent the mean pairwise proximities of eighteen mathematical concepts. The two mean RC-matrices were submitted to the multidimensional scaling procedure to generate two-dimensional graphical representations. These graphical representations are shown in Figure 1 and Figure 2.

In both of the graphical representations of the RC-matrices for Group A and Group B, the nine geometry concepts -- AREA, CIRCLE, CUBE, LINE, PERIMETER, POINT, RECTANGLE, TRIANGLE and VOLUME -- occupied the first and fourth quadrants, while the non-geometry concepts occupied the second and third quadrants. This result indicated that the students in both groups viewed geometry concepts as a distinct set of concepts unrelated to the other mathematical concepts. This could be a reflection of the mathematics curricula introduced to both groups of students. A re-examination of the primary and elementary mathematics textbook series indeed showed that geometry concepts were treated in separate chapters and as distinct topics.

Figure 1 showed that seven of the nine geometry concepts formed a tight cluster and the other two geometry concepts -- POINT and LINE -- lay at a distance from this cluster. The same nine geometry concepts were scattered in the first and fourth quadrants in Figure 2. The Group A students, who were educated in the United States, viewed the geometry concepts as more related to each other than the Group B students, who were from Hong Kong.

Figure 1: Two-dimensional graphical representation of the mean RC-matrix for the students educated in U.S.

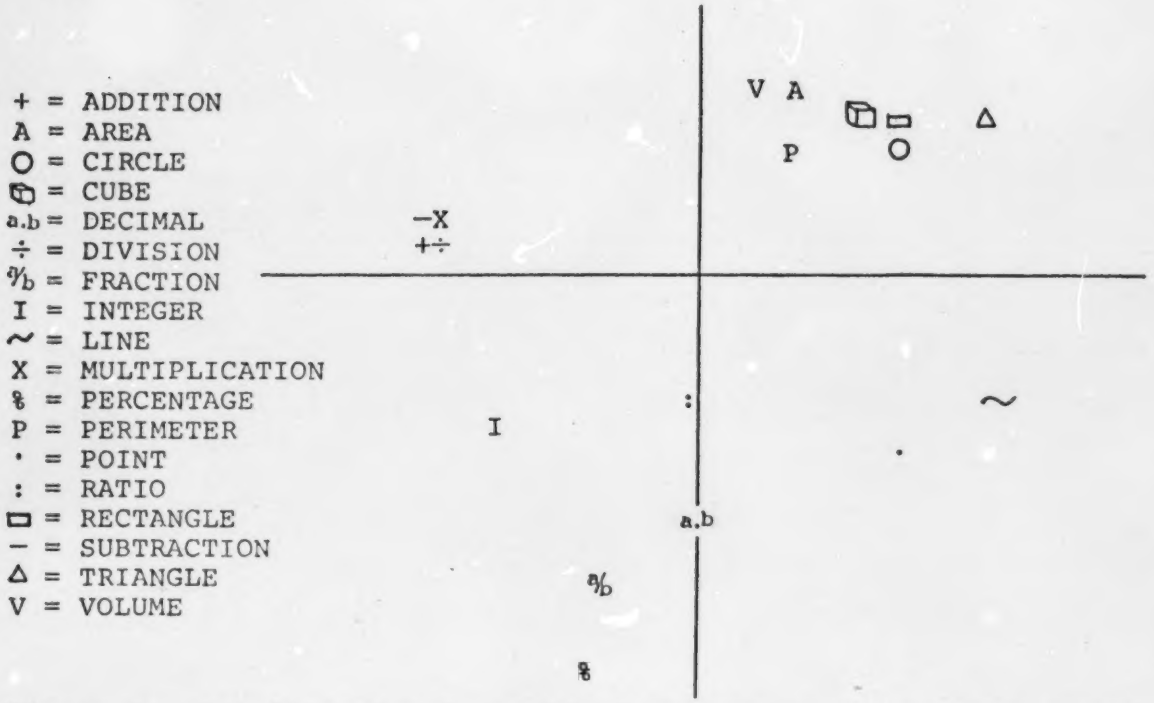
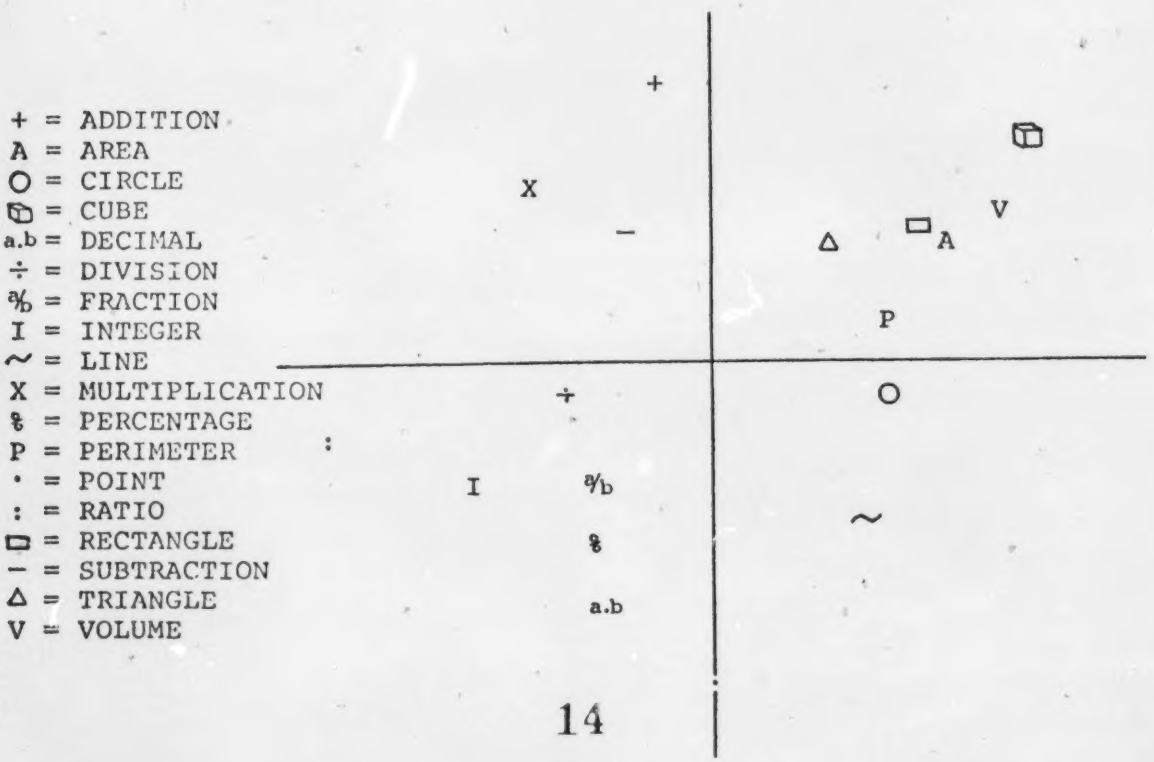


Figure 2: Two-dimensional graphical representation of the mean RC-matrix for the students from Hong Kong.



Similar results were noted when the four basic operations -- ADDITION, SUBTRACTION, MULTIPLICATION, and DIVISION -- were examined. The four concepts almost lay on a unique point in Figure 1, but fell into an elliptical shape with ADDITION and DIVISION far apart in Figure 2. The students from Hong Kong did not see the four operations as related to each other as did the students educated in the United States.

The differences in the mathematical cognitive structures of the two groups, as indicated by the two graphical representations, could be a result of the differences in the primary and elementary mathematics curricula in the U.S. and in Hong Kong. The students in Group A received their mathematics education in the United States, one which introduced the interrelationships and meanings of mathematical concepts in early grade levels. The graphical representation of their mathematical cognitive structure showed that mathematics concepts fell into tight clusters. The students in Group B received their mathematics education in Hong Kong, where computational skills were emphasized. The graphical representation of their mathematical cognitive structure showed that the mathematical concepts were relatively unrelated to each other.

The results on the geometry concepts and the four basic operations could be used to guide the mathematics teachers who have students recently arrived from Hong Kong, especially whose in secondary Chinese bilingual programs. The meaning and the structure of the mathematical concepts should be introduced to

bridge the gap experienced by these students with the mathematics curricula of the United States.

The difference in the relationships of the three concepts -- DIVISION, FRACTION, and INTEGER -- for the two groups of students was also enlightening. The three concepts formed a straight line $\overline{\div I^a/b}$ in Figure 1. The concepts DIVISION and FRACTION were far apart from each other. The same three concepts formed an equilateral triangle in Figure 2. The distance between DIVISION and FRACTION was significantly shorter than in Figure 1. This result suggested that the two groups of students have different conceptions of FRACTION. The difference could also be a result of the different mathematics curricula introduced to the students.

Mathematics educators have, in recent studies (Carpenter, Coburn, Reys & Wilson, 1975a, 1975b; Ginther, Ng, & Begle, 1976), noted that the students of the United States are encountering difficulties in learning fractions. They further advocated more research studies to investigate the effects of different pedagogies and curricula approaches on the learning of fractions. The result of this study indicates that further studies investigating the effects of mathematics curricula on the learning of fractions in different countries could be promising. Possible research areas are studies of error patterns on fraction problems and observations of fraction problem solving procedures.

Conclusion

This is an exploratory study comparing the mathematical cognitive structure of a group of junior high students educated in the United States and that of a group of students recently arrived from Hong Kong. The Word Association technique was employed to retrieve the mathematical cognitive structures from both groups of students. The Word Association data were subsequently converted to two-dimensional graphical representations by the multi-dimensional scaling procedure. The results of the two-dimensional graphical representations indicated that the mathematical cognitive structures of the two groups of students were different. Difference in the mathematics curricula of the United States and Hong Kong was suggested as the possible cause for the difference in the mathematical cognitive structures.

Similar studies should be conducted to confirm the results of the present one. These studies should exercise care in the matching of cross cultural groups. Intelligence, cognitive styles, socio-cultural differences, as well as curricula should all be investigated in relation to the difference in the mathematical cognitive structures. The present study should also be replicated with other ethnic groups for immediate application to bilingual education programs.

REFERENCES

Adams, J. A. Human Memory. New York: McGraw-Hill, 1967.

Begle, E. G., Pence B., Tsang, S. L., & Ginther, J. Stanford Mathematics Education Study Group (SMESG) working paper no. 11: An exploratory analysis of mathematics content structure as it relates to cognitive structure for Chicano Students. Stanford University, California, 1975.

Bousfield, W. A. The occurrence of clustering in the recall of randomly arranged associates. Journal of Genetic Psychology, 1953, 49, 229-240.

Bruner, J. S. et al. (Eds.) Studies in Cognitive Growth. New York: Wiley, 1966.

Carpenter, T. P., Coburn, T. G., Reys, R. E., & Wilson, J. W. Results and implications of the NAEP math assessment. Arithmetic Teacher, 1975a, 22, 438-450.

Carpenter, T. P., Coburn, T. G., Reys, R. E., & Wilson, J. W. Results and implications of the NAEP math assessment. Mathematics Teacher, 1975 b, 68, 453-470.

Cofer, C. N., & Musgrave, B. A. Verbal Behavior and Learning. New York: McGraw-Hill, 1963.

Coombs, C. H. A Theory of Data. New York: Wiley, 1964.

Deese, J. The structure of associations in language and thought. Baltimore: The Johns Hopkins Press, 1965.

Dixon, T. R., & Horton, D. L. Verbal Behavior and General Behavior Theory. New Jersey: Prentice-Hall, 1968.

Geeslin, W. E. An exploratory analysis of content structure and cognitive structure in the context of a mathematics instructional units. Unpublished doctoral dissertation, Stanford University, California, 1973.

Ginther, J., Ng, K., & Begle, E. G. Stanford Mathematics Education Study Group (SMESG) working paper no. 12: A survey of student achievement with fractions. Stanford University, California, 1976.

Kruskal, J. B. Multidimensional scaling by optimizing goodness of fit to a nonmetric hypothesis. Psychometrika, 1964a, 29, 1-27.

Kruskal, J. B. Nonmetric multidimensional scaling: A numerical method. Psychometrika, 1964b, 29, 115-129.

Kruskal, J. B., Carmone, F., & Arabie, P. How to use M-D-SCAL (Version 5M) and other useful information. Stanford Center For Information Processing, Stanford, California, 1976.

Menges, R. J. Student-instructor cognitive compatibility in the large lecture class. Journal of Abnormal and Social Psychology, 1969, 64, 164-170.

Osgood, C. E., Suci, G. J., & Tannenbaum, P. H. The Measurement of Meaning. Urbana, Illinois: University of Illinois Press, 1957.

Profiles of school district performance: California State testing program 1971-1972 & 1972-1973. State Department of Education, Sacramento, California, 1974.

Report of the Cambridge Conference on School Mathematics: Goals for School Mathematics. Boston: Houghton Mifflin, 1963,

Report of the Commission of Mathematics: Program for college preparatory mathematics. College Entrance Examination Board, 1959.

School Mathematics Study Group Newsletter No. 39. Stanford University, California, 1972.

Schuell, T. J. Clustering and organization in free recall. Psychological Bulletin, 1969, 72, 353-374.

Shavelson, R. J. Some aspects of the relationship between content structure and cognitive structure in physics instruction. Unpublished doctural dissertation, Stanford University, California, 1970.

Shepard, R. N. The analysis of proximities: Multidimensional Scaling with unknown distance function, I. Psychometrika, 1962a, 27, 125-140.

Shepard, R. N. The analysis of proximities: Multidimensional Scaling with an unknown distance function, II. Psychometrika, 1962b, 27, 219-246.

The activity which is the subject of this publication was supported in whole or part by the Office of Education, U.S. Department of Health, Education and Welfare. However, the opinions expressed herein do not necessarily reflect the position or policy of the Office of Education, and no official endorsement by the Office of Education should be inferred.